EPIDEMIOLOGY OF TRYPANOSOMAL INFECTIONS IN CAPRINE IN MEDALLO AREA OF THE GHIBE VALLEY, SOUTH WEST ETHIOPIA

BY

BINIYAM MULUGETA ABEBE

A thesis submitted to College of Veterinery Medicine, Mekelle Univeristy, in the partial fulfillment of the requirements for the attainment of the degree, Doctor of Veterinery Medicine (DVM)

June 2010

Mekelle, Ethiopia

Table of Contents

Contents page

LIST OF TABLE **Page**

LIST OF FIGURES

LIST OF ANNEXES Page

LIST OF ABBREVIATIONS

CaST	Capacity Strengthening
FAO	Food and Agricultural Organization
IFAT	Immuno-Florecence Antibody Test
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
MoA	Ministry of Agriculture
PCR	Polymerase Chain Reaction
PCV	Packed Cell Volume
SP	Spinous processes
SPSS	Statistical Package for Social Sciences
STDM	Standard Trypanosome Detection Method
TP	Transverse processes

AKNOWLEDGEMENT

First and for the most I would like to praised the only savior Jesus Christ and his mother St. Merry for their miraculous salivation in my life.

My unadulterated positive reception goes to Dr. Shewit Kalayou and Dr. Wedyalehu Mulatu my supervisors, for their fathomless and wholehearted valuable advise, intellectual guidance, stipulation of materials and painstaking correction of this manuscript, overall, for their changing my outlook and in planting the meaning of hard work.

I am immensely delighted to receive this opportunity to express my earnest approbation and gratefulness to ILRI including its biotechnology department staffs and capacity strengthening (CaST) department staffs for their inestimable cooperation during my field work.

I wish to express every single one sorts of acknowledgement to my much-loved family especially my father Mulugeta and my Mom S/r Bedriya for their collective moral and financial support through out my life.

Finally, I would like to give my enormous appreciation to my friend Frehiwot Zelalem for her constrictive moral and support in doing my work.

ABSTRACT

Trypanosomosis is one of the major diseases hindering livestock production in Africa. Many studies have been carried out on the prevalence of the disease in cattle but very little has been done in small ruminants. A Cross sectional epidemiological survey of Caprine trypanosomosis was conducted from November 2009 to March 2010 in Nono district, Medallo area at Ghibe research site of the International Livestock Research Institute (ILRI), southwest Ethiopia, to investigate the existence and prevalence of Caprine trypanosomosis on the study area. A total of 400 blood samples were collected and the blood films were examined by Buffy coat technique for the detection of trypanosomes. The study conducted on 400 goats revealed that 4 (1%) of the goats were found to be infected with trypanosomes. Up on examination on thin smears of infected blood, *Trypanosome congolense* was the only species found. Infection rate of age, sex, color and body condition scoring did not reveal significant difference (P>0.05). Thus based on the findings of the study some recommendations were forwarded aiming at the attentions to be given in the prospect of the disease in the small ruminants in the country.

Key words: Ghibe / ILRI / Medallo/ / Prevalence rate/ Trypanosomosis /

1. INTRODUCTION

Ethiopia has the largest domestic animal population in Africa, with 31 million cattle, 23.2 million Sheep, 18.1millonHorses, 0.63millions Mules, 5.2 million Donkeys, and 1.07millon camels (FAO, 1998). Of the total cattle, sheep and goats population in Africa, 15%, 11% and 10% are found in Ethiopia respectively (ILRI, 2000). 88% of the national farming population lives on the high land areas, which occupy 40% of the country's total area (Getachew et al., 2004).

The distribution of small ruminants in Ethiopia varies largely in different agro-climatic conditions. The highlands have 75% of the sheep but only 27% of the goats while the lowlands accommodate 25% and 73% of the total sheep and goats' population of the country respectively (Coppock, 1994; ILCA, 1993). Hence, an increase in small ruminants production could contribute to the attainment of food self sufficiency in the country particularly in response to the protein requirement for the growing human population as well as to enhance the export earnings (ILCA, 1993).

Small ruminants play an important role in improving the economy of the small farmers, for those who are unable to keep larger animals such as cattle. Goats provide meat, milk, skins, manure and play an important role as liquid assets and source of saving as well as having important religious and social functions like payment of dowry, celebration and gift. Households may liquidate them in times of stress; during drought and agricultural crop failure (Osaer et al, 1999). They can survive in a broad ecological zone range including harsh environment, utilize area which are unsuitable for crop production and feed on a variety of grasses, herbs and shrubs (Oyeyemi, 2002).

Currently, animals are the major income for the poor peasant families in Ethiopia. Among these animals goats are the relevant species for those living in a tropical and harsh environment, in which goats withstand tropical climate and supply benefit for their owners. However, peasants who live in the tsetse-infested area encountered the problem of tsetse and the trypanosomosis as one of the major constraints of livestock and crop production. They have been experiencing dramatic losses of their goats due to this disease which increase mortality and reducing fertility. Under village condition, the

effects of trypanosomosis adversely affect people's health, welfare, food security and impede their socioeconomic development. Goats being important components of livestock sub-sector play a significant role in the socio economy of the developing countries. Their great popularity in these countries can be explained by their better adaptation to the unfavorable arid environment and their suitability for resource poor farmers (Gall, 1981).

Parasitic diseases continue to be a major constraint in the world, especially in poor developing countries. Their effects are characterized by lower out put of animal products, by-product, and traction, all contributing to look of food security (Getachew et al., 2004).

Among the parasites, trypanosomosis is arguably the single most disease constraint of animal production and productivity. In Ethiopia, tsetse – borne trypanosomosis is the single most important disease, which excludes over 150,000 – 200,000 Km^2 fertile land in the west and south west of the country from agricultural production (MOA, 1996). Some 10 – 40 million heads of cattle in Ethiopia, and an equivalent number of small ruminants together with a significant number of equines and camels are exposed to the risk factors of the disease (MOA, 1996).

Tsetse transmitted trypanosomosis is one of the most ubiquities and important constraints to agricultural development in sub humid and humid zone of Africa (Swallow, 2000). Here in Ethiopia trypanosomosis is referred as 'Ghendi' and it is a serious constraint to cattle and small ruminant production in tsetse infested; southwestern part of the country (Abebe & Jobre, 1996).Ethiopia is one of 37 sub–Saharan Africa countries now harboring about six species of trypanosome species. In Ethiopia especially south west, the low lands are infested by tsetse flies. Livestock and crop production are greatly hampered, total land area roughly estimated to be 135,000 – 220,000 sq. Km or 16.5%; and cover the country. Trypanosomosis is a serious disease that affects human and domestic animals caused by different species of trypanosomes and characterized by intermittent fever, anemia, lymphadenopaty, cachexia and splenomegaly often followed by death in untreated case. The disease is a group of infections but non-contagious except dourine (non-tsetse transmitted trypanosomosis) in equines (Radostits et al., 2000).

The epidemiology of Africa trypanosomosis is almost entirely dependent on tsetse flies. But with in the general ecological limits of distribution the problem of trypanosomosis is not static. The natural host of salivarian trypanosomes usually shows no clinical sign of infection, host and parasites being in equilibrium. The large numbers of naturally infected wild animal hosts constitute a huge reservoir of trypanosomes. Once infected, tsetse remains so for life and thus they too form a reservoir of infection. Consequently, when domestic animals are introduced into area in which Sylvatic cycles of trypanosome transmission occur, trypanosomosis always emerges as a serious disease (Jaw. C and RC Tustin, 2004).

An animal entering a tsetse infested area risks becoming infected with potentially pathogenic trypanosomes may produce disease. The degree of risk depends largely on the 'challenge'. True challenge or risk is determined by the interaction of the number of infected tsetse bites, host preference, host susceptibility and the virulence of the parasite. There are also various reasons why a particular animal species may be subjected to greater challenge than another. The behavior of a potential host can influence the ease with which a tsetse can engorge and this may contribute to observed preference (Jaw. C and RC Tustin, 2004).

For many years, it was widely believed that goats were little affected by trypanosomosis. These small ruminants survive light to medium tsetse challenge without any specific intervention to reduce or remove tsetse flies or the infection that they transmit (Stephen, 1970). Trypanosomal infection in goats is sometimes difficult to detect because of the low parasitaemias that occur. However, the disease in goats produce acute, sub acute, chronic or sub clinical forms, being *trypanosome vivax, trypanosome congolense* and *trypanosome evansi,* the most invasive trypanosomes for goats. Also untreated goats often revealed pale mucous membranes and a rapid thready pulse; enlarged prescapular lymph nodes are easily palpable in many chronically affected goats (Dinka and Abebe, 2005).

Goat has been reported to be resistant to trypanosomosis. However, several studies on the prevalence of trypanosomosis in goats in different countries including Nigeria, Ethiopia,

and Kenya revealed that goats acquire natural infection resulting in economic losses (Irungu et al., 2002). Infected goats that survive the infection become reservoir of the parasite for other domestic animals as well as human beings. Goats have been experimentally infected with trypanosomes in studies of experimental trypanosomosis to observe how the infection affects different body parameters such as live weight, birth weight, and reproductive performance like abortion and stillbirth. The experimental infection also affects the hematological changes observed including anemia, red blood cell count, hemoglobin level, and lower packed cell volume in different breeds of goat (Azab and Abdel-Maksoud, 1999).

The opportunity given by international livestock research institute (ILRI) for a short term project on trypanosomosis in goats at the Ghibe valley Medallo area was due to the limited research program on goats at this station that appropriate research is needed to assist peasants in order to improve better production.

There for the objectives of this study were-

- ✓ To evaluate the present prevalence rate of trypanosomosis in the study area.
- ✓ To assess the major risk factors associated.
- ✓ To know the epidemiology of goat trypanosomosis in the area (Medallo).

2. MATERIAL AND METHODS

2.1 Study area

The study area on the epidemiology of Caprine trypanosomes was conducted in an area namely Tolley/Gullele, Nono district, Medallo kebelle, Oromia national regional state, south west of Addis Ababa.

The study area is located in the lowland areas of the Nono district, Medallo area which is situated about 230km south west of Addis Ababa with in the altitude range of 1500-1600 meters above sea level bordering the Ghibe river system. The district is located latitude $8^0$50'N and longitude 37°45'E. The area covers about 50,000 hectares of land with the total population 250,494 (population density). Topographically the area is marked by hilly, flat, sleep slopes and gorges and a number of streams. The area has a sub-humid climate and a moderately hot temperature with a mean annual temperature of 20°c. The highest average monthly temperature occurs in January when the mean maximum temperature is 28°c.The coolest month is August when the average monthly minimum temperature is 12°c. It receives high and reliable annual rainfall averaging 1100mm/annum with low inter annual variation.

The livestock species in the area include bovine, Caprine, ovine and equine (donkey). But, the predominant species in the area are bovine and Caprine. Livestock management system is mixed farming system that the local human populations are principally engaged in livestock crop (mixed) farming system. Cattle and goats are the mostly kept animals in the study area that the animals in the area mainly depend upon communal grazing field as feed source and watering points are the tributaries of large rivers.

Figure 1. Goats and cattle grazed in bushed grassland at Medallo area

2.2 Study animal (population)

Animals involved in the study were goats of all ages and sexes. According to the data collected from Nono district, in Medallo area there were about 600 small ruminant populations; among these about 400 were Caprine and the remaining 200 were ovine. Hence, 400 Caprine were examined from Nov 2009 to March 2010 for the presence of trypanosomosis. Of the 400 animals, examined 244 were males and 156 were females. They were kept under extensive system of management that they graze extensively on shrubs and pasture around the Ghibe River. The animals also graze the communally owned pasture land throughout the year. They are managed under the same agro-ecology without any supplementary feeding.

2.3 Study design

2.3.1 Sampling method and sampling size

The study design for this laboratory based survey was a cross sectional study, which was conducted to determine the prevalence and epidemiology of Caprine Trypanosomosis in the study area (Medallo).

The sampling method applied was a census that the whole populations of goats in the study area were examined and the census size was determined by using 50% expected prevalence and 95% level of confidence with desired absolute precision 5% (Thrusfield, 1995).

The formula used is shown below:-

$$n = \frac{(1.96)^2 P_{exp} (1-P_{exp})}{d^2}$$ Taking 95% confidence interval

Where, n= required sample size

P_{exp}= expected prevalence

d^2= desired absolute precision (5%)

2.4. Study protocol

A cross sectional study was conducted to determine the prevalence and epidemiology of Caprine trypanosomosis. Based on the facilities available in the institute the following diagnostic methodologies were performed in order to cross check the overall trypanosomal infection load on those Caprine and to determine which species of trypanosome show a greater prevalence in Caprine at the study area.

2.4.1. Routine clinical examination

Although in many tsetse-infested areas diagnostic facilities are not readily available, clinical signs of Trypanosomosis are well recognized. Such clinical signs were recognized during the study period by visual and physical (palpation) inspection of every sampled animal for Caprine trypanosomal infection. The diseased animals revealed mainly anemia and poor body conditions.

2.4.2. Parasitological and Hematological survey

To determine the prevalence of Caprine trypanosomosis cross- sectional parasitological and Hematological survey was conducted. Blood samples were collected after properly securing the animal and aseptically preparing around the ear vein. Blood sample were obtained by puncturing the ear veins using sterile blood lancet and sucked up by heparin zed capillary tubes. A pair of capillary tubes was filled with blood from animals until the tubes are filled to three forth of their height and sealed at one end with crystal seal. Then the capillary tubes were loaded on the microhematocrit centrifuge symmetrically and centrifuged at 12,000rpm for 5minutes (Woo, 1996).

Packed cell volume (PCV) was determined using hematocrit reader After the PCV was read, capillary tubes were broken 1mm below the Buffy coat using diamond pencil to include the red blood cell layer and the content were expressed on microscopic slide and covered with a 22x22mm cover slip. The content was examined under (x40) objective using dark ground Buffy coat technique. From positive samples, thin blood smears were made, fixed with methanol for 5minutes, stained with Giemsa solution for 30minutes, and examined using oil immersion under x10objective to detect the species of trypanosomes. (Woo, 1996).

3. DATA MANAGEMENT AND ANALYSIS

The data collected from the study area were entered in to MS-excel spread sheets and analyzed using SPSS statically soft ware. Chi-square test were applied to test statically significant association exist between risk factors such as age, sex, body condition scoring, and their coat color with trypanosomosis positivity. For all the analysis performed, $P \leq 0.05$ were taken as statistically significant (Thrusfield, 1995).

4. RESULTS

In the study area the over all prevalence of trypanosomosis was 4 (1%) from 400 animals examined. Species based prevalence of the diseases indicate 1% of goat were positive for *trypanosome congolense.* From this result *trypanosome congolense* was the main trypanosome species identified in the study area.

Table 1: prevalence of Caprine trypanosomosis in the study area

Site	Sampled animals	infected	Trypanosome species		Prevalence rate
			T. congolense	T. vivax	
Medallo	400	4	4	0	1%

The chi – square test showed that there was no statically significant difference in infection rate between different sex groups ($x^2 = 0.202$, P>0.05) (table 2).

Table 2: Prevalence of Caprine trypanosomosis on sex basis

Sex	Sampled animals	Infected	Negative	% Positive
Male	244	2	242	0.8%
Female	156	2	154	1.3%
Total	400	4	396	1%

$X^2 = 0.202$, P = 0.653

The chi – square test showed that there was no statically significant difference in infection rate between different age groups ($x^2 = 2.733$, P>0.05) (table 3).

Table 3: Prevalence of Caprine trypanosomosis on age basis

Age (Years)	Sample size	Infected	Prevalence (%)
< 2 years	238	4	1%
2-4 years	125	0	0%
> 4 years	37	0	0%
Total	400	4	1%

$X^2 =$ 2.733 , P = 0 .255

The PCV value of individual Caprine was tested. Out of 400 tested goats, 85.2% had PCV value greater than 22% and 15% had PCV value less than 22%. The mean PCV of total parasitaemic and aparasitaemic goats was found to be 27.4% and 26% respectively.

Table 4: Relation of PCV with trypanosomosis infection

Parasitamenia	PCV value in Percentage				Total sample
	15-21	21-26	26-31	31-36	
Positive	0	2	1	1	4
Negative	30	150	147	69	396
Total sample	30	152	148	70	400

$X^2 =$ 0.749, P= 0 .862

In general Statical analysis undertaken indicates that there is no significance difference (P > 0.05) between the sex, age, color and body condition scoring association in prevalence of trypanosomosis.

5. DISCUSSION

Farmers in the study area keep goats flock of mean size ranging from 5-10. The same range has been reported in Tanzania, Nigeria, Cameroon, and Gambia (Mathewman 1980, Ndamukong 1987; Rawlings et al., 1992). The small flock size may be due to problems encountered in livestock production which include water and land scarcity, risk of predators, conflict between livestock keepers and diseases.

Human activities such as bush clearing intended for buildings and cultivation disturb the habitat for tsetse, which transmit trypanosomosis (Reid et al., 2000 and Thornton et al., 2006). In the study area goats were grazed at the bush grassland area which is good habitat for tsetse fly. In Tanzania namely *Glossina morsitans centalis* and *Glossina morsitans morsitans* are found in bushy grass land (Rodgers and William 1993 and Ministry of Agriculture and Co-operatives 1998).

Results obtained during this study showed that there are less (1%) cases of trypanosomosis found in sampled goats. This may be due to several factors including the study season i.e. dry season, by which tsetse fly (vector) density is lower in dry seasons than rainy season, the low feeding success of tsetse on goat related to the small size and anti-feeding behavior such as leg kicks and stamping, tail and ear flicks, head movement and skin rippling (Vale, 1977 and Snow et al., 1996). Also biting flies prefer cattle than small ruminants on account of larger size. In communal grazing area they attack cattle and leave most of the small ruminants uninfected (Kniepert, 1981). Goats are considered resistant to trypanosome infection, showing only a mild or sub clinical manifestation of disease under natural condition (Stephen, 1970; Oladele and Adenegan 1998). According to the study done by Sinshaw et al., (2006) on the prevalence of trypanosomosis in cattle, small ruminants and equidae, it was revealed that the problem of diagnosis in sheep and goats may be due to existence of some degree of trypanotolerance.

Another reason for the reported low prevalence (1%) of trypanosomosis in goats may be due to the weakness of the diagnosis method used, the Standard Trypanosome Detection Methods (STDM). The study done by Connor (1985) on trypanosome prevalence rates in

cattle, goats and sheep in Mtwara and Lindi district (Southern Tanzania) using thick and thin blood smears revealed no parasite out of 208 goats sampled. Another study done by Fison (1987) on the prevalence of Trypanosomosis in Southern Highlands Region in Tanzania by using the Buffy coat method showed one (1.3%) goat out of 76 goats sampled had the parasites while by using IFAT method out of 514 goats twenty (3.9%) had the parasites. In the study done by Ng'ayo et al., (2005) on the prevalence of trypanosomosis in small ruminants in Kenya it was demonstrated that by using microscopic method the number of positive samples was five whereas using PCR method number of positive samples increased to 86 out of 402 animals sampled.

Farmers in the study area use diminazene aceturate for control of tick borne diseases and trypanosomosis. The absence of positive cases in the study area may be contributed to by the use of combination of acaricide and antitrypanosomal drugs (Ilemobade, 1988). Deltamethrin has been reported to reduce tsetse fly population by 99% and the trypanosomosis cases in Mkwaja ranch in Tanga region and NARCO ranches in Kagera and nearby farming areas in Bukoba and Karagwe districts (Thompson, 1987; Ministry of Agriculture and Co-operatives 1998).

In the study area the average PCV obtained was 27%. The minimum and maximum PCV from the area was 18% and 36% respectively. With exception of a few goats most of them (342) have the PCV within the normal range of 22-38% for goats (Dinka and Abebe 2005). The lowest PCV was found in goats which were tethered around the homestead and in those flocks where deworming was not done. The low PCV could be due to high worm infestation and nutrition deficiency. Tethering of goats results in nutritional deficiency, poor body condition, stunted growth and increased contamination of the area with worm eggs infestation due to lack of enough pastures (Fritsche et al., 1993; Kusiluka, 1995 and Wassink et al., 1997).

Taylor (1998) indicated that anemia persists during the chronic stages of infection when parasitaemia is generally quite low, probably because different mechanisms are involved in its genesis during the acute and chronic stages of infection. This suggests that control

of parasitaemia and control of anemia is unrelated in the chronic phase when immune infections are depressed and anemia is sustained through dyserythropoiesis. In the present study, infected and/or non infected goats' PCV was negatively associated with sex, age and color.

PCV had strong positive association with the body condition scoring of the goats and there was a low body condition score in *T. congolense* infected animals than non-infected groups. This variation in PCV in relation to body condition indices would be important if considered with the aspect of predisposing factors to *T. congolense* infection and taking PCV as one major criteria of assessing *Trypanosoma* infection. In general, the present findings indicate that small ruminants are at a higher risk of infection and development of the disease in the study area.

The major limitations of the study were the short study period of five months (November to March). In order to get better results the study would have taken longer period at least 12 months to take care of seasonal changes. In trypanosomosis studies it is better to compare two seasons since the distribution of tsetse flies varies with seasons. Tsetse fly density is higher in rainy seasons than dry season resulting in higher and lower rates of trypanosomosis infection respectively. The method used for the diagnosis had limited sensitivity. It is recommended to use the combination of serological and Buffy coat methods for the diagnosis of trypanosomosis to confirm absence or presence of the trypanosomes in the area so that farmers can be advised accordingly.

6. CONCLUSION AND RECOMMENDATIONS

The result of the present study revealed that trypanosomosis is not important problem for got production in the study area that goats are highly resistant for trypanosomal infection. Two species of tsetse flies i.e. *G. pallidipes* and *G. fuscipes* were caught, of which *G. fuscipes* is considered the main vector of the pathogenic trypanosome in the area, biting flies in the area such as stomoxis were also caught, and these are considered very important for the possible mechanical transmission of the disease. The prevalence of goat trypanosomosis was found to be equal level in both sexes. The mean PCV value indicated an overall poor health status of livestock in the study area and the trypanosome infection has been found to cause further poor condition by declining the PCV value among the infected goats. *Trypanosoma congolense* was found to be most prevalent trypanosome species in the area.

Based on the conclusion made above the following recommendations are forwarded:

- Designing and implementing of control strategies of trypanosomosis focusing on sustainable, community based, simple, cost effective, and integrated approach (vector control and chemotherapy) should be undertaken in the upper Ghibe valley of western Ethiopia (Nono district).
- Proper and strict follow up of trypanocidal drugs treatment should be conducted by professionals and supervision of the field personnel by experts should be practiced. The delivery and distribution of trypanocidal drugs need special attention to avoid misuse.
- Further studies should be carried out in the area of assessing the diurnal actives pattern of tsetse fly and drug resistant which will have essential roles for overall control of tsetse transmitted trypanosomosis in the upper Ghibe valley of Western Ethiopia.

7. REFERENCES

Abebe, G and Jobre, Y., (1996): Trypanosomosis: A threat to cattle production. Rev.vet, **147**: 897-902.

Azab, M. E. and Abdel-Maksoud H. A., (1999): Changes in some hematological and biochemical parameters during pre-partum and post-partum periods in female Baladi goats. Small Ruminant Research **34**: 77-85.

Connor R. J, (1985): Report on work conducted by the Veterinary Investigation Centre, Mtwara, Southern Tanzania, ODA, UK.

Coppock, D.L., (1994): The Borena plateau of southern Ethiopia; Sunthesis of pastoral research development and change, 1980-1991.

Dinka, H. and Abebe G., (2005): Small ruminants trypanosomosis in the southwest of Ethiopia. Small Ruminant Research **57**: 239-243.

FAO, (1998): A field guide for the diagnosis, treatment and prevention of African Trypanosomosis.

Fritsche T, Kaufmann J. and Pfister K, (1993): Parasite spectrum and seasonal epidemiology of gastrointestinal nematodes of small ruminants in The Gambia. Veterinary Parasitology **49**: 271-283.

Fison, T. W, (1987): Report of investigations carried out by the Veterinary Investigation Centre, Naliendele, Near Mtwara, and Southern Tanzania 1984-1986. ODA, UK.

Gall.C, (1981): Goats in Agricultural, Distribution, importance and Development. Goat prod Academic Pres. 1-8.

Getachew, Abebe, Malone, J.B., and Thomson, A.R., (2004): Geospatial for cost model for tsetse-transmitted animal Trypanosomosis in Ethiopia.SINET, Ethio.J.Sci.pp.76,93and94.

ILCA, (1993): Hand Book of African livestock statistics.

Ilemobade, A. A, (1988): Chemotherapy against African animal trypanosomosis: Its strengths and limitations: In the African Trypanotolerant Livestock Network; Proceedings of a meeting held 23-27 November 1987 Nairobi, Kenya.

ILRI (International Livestock Research Institute), (2000): Hand book of livestock statistics for developing countries. Socio-economics and policy research working paper 26. ILRI, Nairobi, Kenya.299p.

Irungu P, Nyamwaro S. O. and Masiga D. K., (2002): Financial Implication of rearing sheep and goats under natural trypanosomosis challenge at Galana ranch Kenya. Tropical Animal Health and Production **34**: 503-513.

JAW, C. and RC TUSTINS (2004): Infectious disease of livestock, 2nded/vol 1, Oxford University presses South Africa.

Kniepert, F. W, (1981): Preference behavior of female tabanids (Diptera, Tabanidae) on the host, Z. Angew. Entomology 91 (1981), 486-510 pp.

Kusiluka, L. J. M, (1995): Management systems and health problems of goats in Morogoro District. PhD thesis, Edinburgh, UK. 5-10pp.

Matthewman, R. W, (1980): Small ruminant production in the humid tropical zone of southern Nigeria. Tropical Animal health and production in Africa **12**: 234-242

Mike, S. (1996): Goats. In the tropical Agriculturalis. Macmillan, TCTA, pp, 79-83.

Ministry of agriculture (MOA), (1996): National policy and strategies for Trypanosomosis control.

Ministry of Agriculture and Co-operatives (1998) 13th Co-ordination Meeting on Farming in Tsetse Control Areas of East Africa. Kampala, Uganda 7-8 May 1998. Prepared by Tsetse and Trypanosomosis Control Section, Dar es Salaam.

Ndamukong, K. J. N, (1987): Sheep and goat production in the North West provience of Cameroon with special reference to parasitic gastroenteritis. PhD thesis. University of Edinburgh.

Ng'ayo M O, Njiru Z K, Kenya E U, Muluvi G M, Osir E O and Masiga D. K, (2005): Detection of trypanosomes in small ruminants and pigs in western Kenya important reservoirs in the epidemiology of sleeping sickness? Kinetoplastid Biology and Disease at http://www.kinetoplastid.com/4/1/5 visited on 12th may 2006.

Oladele, O. I and Adenegan K. O, (1998): Implications of small ruminant farmer's socio-economic characteristics for extension services in South Western Nigeria. In: The Nigeria Livestock Industry in the 21st Century. Ologhobo A D and Iyayi E A (editors). Publication of Animal Science Association of Nigeria, Lagos. Nigeria. 243-246 pp.

Osaer S, Goossens B, Kora S, Gaye M and Darboe L., (1999): Health and productivity of traditionally managed Djallonke sheep and West African dwarf goats under high and moderate Trypanosomosis. Veterinary Phraseology **82**(2): 109-119.

Oyeyemi, M. O., (2002): Response of multiparous and primiparous West African Dwarf goats (*Capra hircus* L.) to concentrate supplementation Veterinarski Archiv **72**(1): 29-38.

Radostits, O.M., Gay, C.C., Blood, D.C., and Hinchliff. K.W., (2000): Veterinary medicine. A text book of the disease of cattle, sheep, pigs, goats and horses, (9^{th}) ed. Biaillier tindall UK. Pp. 1335-1336.

Rawlings, P. Agyemang K, Clifford D, Bojang N, Tamba A, and Ceesay M, (1992): Ownership patterns and management of small ruminants, equines and pigs in Gambia. African livestock research **2**: 50-56.

Reid, R. S, Kruska R L, Deichmann U, Thornton P K and Leak, S. G. A, (2000): Human population growth and the extinction of the tsetse fly. Agricultural Ecosystems and Environment **77**: 227-236.

Rodgers, D. J. and Williams B. G, 1993 Monitoring trypanosomosis in space and time. Parasitology, 106 (Supplement): S77-92.

Sinshaw, A, Abebe G, Desquesnes M. and Yoni. W, (2006): Biting flies and Trypanosoma vivax infection in three highland districts bordering Lake Tana, Ethiopia. Veterinary Parasitology article in Press at http://www.sciencedirect.com/science visited on 18^{th} July 2006.

Snow, W. F, Wacher T. J. and Rawlings P, (1996): Observations on the prevalence of trypanosomosis in small ruminants, equines and cattle in relation to tsetse challenge, in The Gambia, Veterinary Parasitology **66** (1-2): 1-11.

Stephen, L. E., (1970): Clinical manifestation of the Trypanosomosis in livestock and other domestic animals: In the African Trypanosomosis. H. W. Mulligan (editor). George Allen and Unwin/ODA, London. 774-794 pp.

Swallow, B. (2000): Impact of Trypanosomosis on African agricultural. PAAT Technical and scientific series. No.2. Rome, Italy: FAO.

Taylor, K.A., (1998). Immune responses of cattle to African trypanosomes: protective or pathogenic? *International Journal for Parasitology*. **28**: 219-240.

Thompson, M. C, (1987): The effect on tsetse flies (Glossina species) of Deltamethrin applied to cattle either as a spray or incooperated into ear tags. Tropical Pest Management **33**: 329-335.

Thornton P, Robinson T, Kruska R, Jones P, McDermott J, Kristjanson P. and Reid R, (2006): Cattle trypanosomosis in Africa to 2030. Foresight project: Infectious Diseases: preparing for the future at www.foresight.gov.uk visited on 12th July 2006.

Thrusfield, M. (1995): Veterinary epidemiology. 2nd ed. Black well science, UK.

Vale, G. A, (1977): Feeding responses of tsetse flies (Diptera: Glossinidae) to stationary hosts. Bulletin of Entomological Research, **67**: 635-649.

Wassink, G. J, Fishwick G, Parkins J J, Gill M, Romney D L, Richard D. and Holmes P. H, (1997): The patho-physiology of Trypanosoma congolense in Scottish Blackface sheep: influence of diet on digestive function. Animal Science **64**: 127-137.

Woo, P.T.K. (1996): The hematological centrifugation technique for the detection of trypanosomes. Can.J. Zool, **47**: 921-923.

8. ANNEX

Annex 1: Determining the age of the goat (Mike Steel, 1996)

Age group	Teeth condition
Kid under 1 year	Eight sharp incisors
Yearling (1-2 years)	Central pair of body teeth replaced by permanent ones
Young adult (3-4years)	4 permanent teeth
Adult (4-5years)	8 permanent teeth
Older adults > 5years	Worn teeth and some missing

Annex 2: Body condition scoring of shoats (Mike Steel, 1996)

Condition score	Body conditions	
Starving	0	Extremely thin; nearly dead; no muscle between skin and bone
Very thin	1	SP sharp sticks up. TP are sharp and your fingers easily pushed under thin end. There is hollow between the end of each processes, lion muscle are shallow.
Thin	2	SP feel less sharp; your fingers can be pushed under the TP with the little pressure, lion muscles are of moderate depth.
Moderate	3	SP only sticks up very slightly; they are smooth and rounded. Firm pressure is needed to detect each one separately. TP are smooth and well covered; firm pressure is required to push your fingers under the ends, lion muscles are full.
Fat	4	SP can just be felt with firm pressure as hard line and level with the flesh on either side. The end of the TP can not be felt, lion muscle are full.
Very fat	5	Sp can not be felt at all, TP can be felt; lion muscles are very fully developed.

SP= Spinous processes TP= Transverse processes

Annex 3: PCV determination method and Buffy coat technique (Woo, 1996)

- Take a blood sample using sterile lancet and capillary tube from ear vein.
- Filled A pair of capillary tubes with blood from animals until the tubes is filled to three forth of their height and seal at one end with crystal seal.
- Locate capillary tubes on the microhematocrit centrifuge symmetrically and centrifuge at 12,000rpm for 5minutes.
- Packed cell volume (PCV) was determined using hematocrit reader
- After the PCV read, capillary tubes are broken 1mm below the Buffy coat using diamond pencil.
- Express the content on microscopic slide and cover with a 22x22mm cover slip.